

SHIP PRODUCTION COMMITTEE
FACILITIES AND ENVIRONMENTAL EFFECTS
SURFACE PREPARATION AND COATINGS
DESIGN/PRODUCTION INTEGRATION
HUMAN RESOURCE INNOVATION
MARINE INDUSTRY STANDARDS
WELDING
INDUSTRIAL ENGINEERING
EDUCATION AND TRAINING

June 1976
NSRP 0002

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

Proceedings of the REAPS Technical Symposium

Paper No. 19: The Application of Numerical Control Systems to Plan Production, or N/C Part Definition can Mean Plans Too!

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE JUN 1976		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE The National Shipbuilding Research Program: Proceedings of the REAPS Technical Symposium Paper No. 19: The Application of Numerical Control Systems to Plan Production, or N/C Part Definition Can Mean Plans Too!				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Surface Warfare Center CD Code 2230 - Design Integration Tools Building 192, Room 128 9500 MacArthur Blvd Bethesda, MD 20817-5700				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR	18. NUMBER OF PAGES 39	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

DISCLAIMER

These reports were prepared as an account of government-sponsored work. Neither the United States, nor the United States Navy, nor any person acting on behalf of the United States Navy (A) makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness or usefulness of the information contained in this report/manual, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or (B) assumes any liabilities with respect to the use of or for damages resulting from the use of any information, apparatus, method, or process disclosed in the report. As used in the above, "Persons acting on behalf of the United States Navy" includes any employee, contractor, or subcontractor to the contractor of the United States Navy to the extent that such employee, contractor, or subcontractor to the contractor prepares, handles, or distributes, or provides access to any information pursuant to his employment or contract or subcontract to the contractor with the United States Navy. ANY POSSIBLE IMPLIED WARRANTIES OF MERCHANTABILITY AND/OR FITNESS FOR PURPOSE ARE SPECIFICALLY DISCLAIMED.



UMTRI

70060

**Proceedings of the
REAPS Technical Symposium
June 15-16, 1976
Atlanta, Georgia**

Research and
Engineering for
Automation and
Productivity in
Shipbuilding

**IIT RESEARCH INSTITUTE
10 WEST 35 STREET
CHICAGO, ILLINOIS 60616**

**Transportation
Research Institute**

© 1976

IIT RESEARCH INSTITUTE

ALL RIGHTS RESERVED - NO PART OF
THIS BOOK MAY BE REPRODUCED IN ANY
FORM WITHOUT PERMISSION IN WRITING
FROM IIT RESEARCH INSTITUTE EXCEPT
TO QUOTE BRIEF PASSAGES IN CONNECTION
WITH A REVIEW FOR A TRADE PUBLICATION
OR THE PRESS

THE APPLICATION OF NUMERICAL CONTROL SYSTEMS TO PLAN PRODUCTION
OR
N/C PART DEFINITION CAN MEAN PLANS TOO!

Albert P. Wickham
and
Raymond W. Kucharski
Quincy Shipbuilding Division
General Dynamics
Quincy, Massachusetts

Mr. Wickham is Chief of Computer Applications, a user oriented group responsible for the operation, maintenance and development of technical and manufacturing computer usage. He was formerly Chief of Project Engineering at Quincy and held positions as a naval architect at Quincy and Bethlehem Steel Corporation.

Mr. Kucharski is a Senior Structural Designer with twelve years of hull structural design experience. He has worked as a hull and foundation designer at General Dynamics' Electric Boat Division and at Quincy and on assignment to Mare Island Naval Shipyard and Seatrain Shipbuilding, Inc.

ABSTRACT

Parts definition language used to describe ships parts for N/C fabrication can also be used to assist the designer/draftsman in producing ship's plans. Expanded coding techniques developed by General Dynamics allow the efficient application of the AUTOKON Parts Program to provide the interface between the drafting function and the numerically controlled flat - bed plotter.

BACKGROUND

The use of numerically controlled flame cutters to produce ships parts from steel plate is commonplace in U. S. shipbuilding today. In the majority of yards the data required to control these automated devices is produced by means of a system of computer programs. There are at least four such systems in use in the United States today: AUTOKON I, AUTOKON 71, SPADES and STEERBEAR. Each system provides the ability to store hull geometry data in an accessible data base and a system language to translate pictorial data, as shown on plans, into numerical data acceptable to the flame cutter's numerically controlled director. The individual parts are "coded" using the system language and processed by the computer to prepare N/C control data, usually on punched paper tape. In AUTOKON the **system** module performing this function is termed the Parts Program.

The vocabulary of each of the languages contains geometrical terms such as straight line, circle, tangent start point, direction length end point, etc., easily understood by every shipbuilder. By means of these terms, together with related numerical values such as coordinates and distances, geometrical shapes can be quantitatively defined. A straight line between **two points with coordinates x_1 , y_1 and x_2, y_2** is described in AUTOKON as follows:

Start Point (x_1 y_1) Straight Line: End Point (x_2, y_2).

The languages also include features which simplify the coding effort such as provisions for recalling a series of repetitive steps, files for storing tabular data and FORTRAN-like commands to direct the processing sequence. In addition, the systems make provisions for macro programs, or subroutines, which represent a string of coding which performs some function or creates a geometric shape which will be re-used many times during the process of

coding parts for a vessel. These subroutines may be created, stored in the data base and recalled at will by the coder.

Errors in coding or computer processing are identified by using the pen of a numerically controlled plotter to simulate the torch path of the flame cutter. In this way the numerical data from the computer is reproduced in a form which can be visually verified.

AUTOKON FOR DRAFTING

General Dynamics has been successfully fabricating ship parts from computer produced N/C flame cutting data since 1966. As our knowledge and experience in using the AUTOKON I system has increased over the past ten years, we have made significant changes to improve its efficiency and extend its range of application in our operations. One of the applications of AUTOKON I developed "and implemented at General Dynamics Quincy Shipbuilding Division is the use of the Parts Program to assist in the drafting and production of ship's plans.

The general approach has been to use the AUTOKON system language to describe the basic geometry contained in those views which comprise the plans to be produced for a ship. These views are then drawn on the numerically controlled plotter. This drawing then becomes the original of the plan and is given to the designer/draftsman to complete by the addition of views and details not coded, as well as dimensioning and annotation. The views prepared are primarily of ship structure and use information from the data base such as hull form geometry and the size and location of structural members.

DRAFTING MACROS

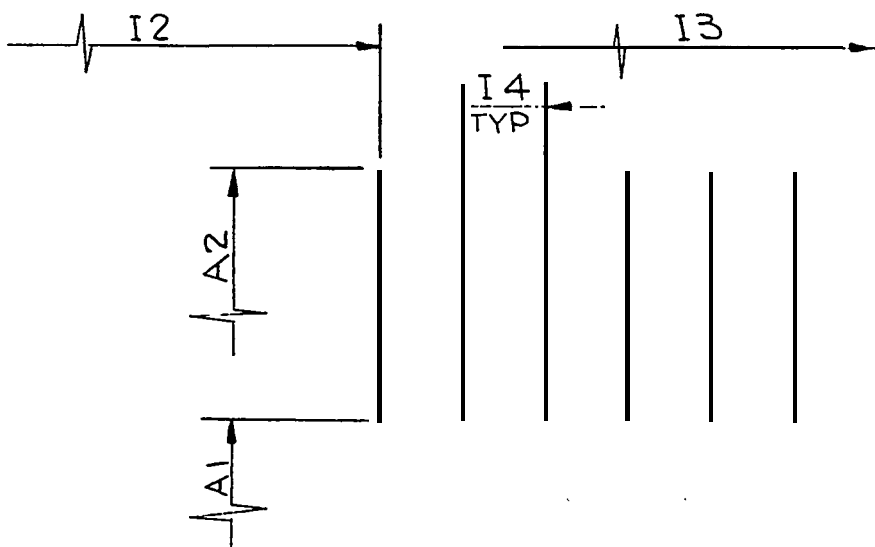
The application of an N/C system to plan production is based on the development of a series of macros devoted to performing certain repetitive drafting tasks. These macros were written as building blocks which condense any number of instructions into a one statement call and which include related entering parameters. The drafting macros were placed in the permanent system library within the data base and assigned a mnemonic title of “DRA” (draw).

DRA's are composed of vocabulary, stored AUTOKON routines and hull definition information from the data base. The ‘DO LOOP’ and testing (jump) capabilities of the parts program were heavily used. The following figures illustrate some of the basic DRA's developed.

Figure 1. DRA 300: DRA 300 draws a series of straight solid vertical lines. Five parameters were used. The first three, 12, 13 and 14 are the equivalent of FORTRAN “DO LOOP” indices. Each time the detail, in this case a straight line, is terminated **I2 is modified by I4 and the detail is repeated until $I2 \geq I3$. i.e.,** for DRA 300, 6-inch (14) is added to 6 feet (12) as long as the sum **is \leq 12-feet 6-inches (I3).** The last two, **A1 and A2,** are arguments which provide numerical values for variable names used in the coding. i.e., for DRA 300 the number 6-feet is entered in A1 and 12-feet 6-inches for A2.

Figure 2. DRA 301: To draw straight solid horizontal lines, DRA 301 was added to the menu of macros. The logic of the entering arguments is similar to DRA 300.

Sketch



Parameters

I2 MIN DISTANCE IN X DIRECTION
 I3 MAX DISTANCE IN X DIRECTION
 I4 INCREMENTAL DISTANCE
 A1 MIN DISTANCE IN Y DIRECTION
 A2 MAX DISTANCE IN Y DIRECTION

Comments

EXAMPLE DRA 300,+6F,+12FGI,-6I(+6F+12FGI)
 DRA 300,-6F,-12FGI,-6I(-6F-12FGI)

AUTOKON

Coded by
 S. ENDRIS

Company
 GD QUINCY

Date
 8-14-72

Usage
 DRAFTING

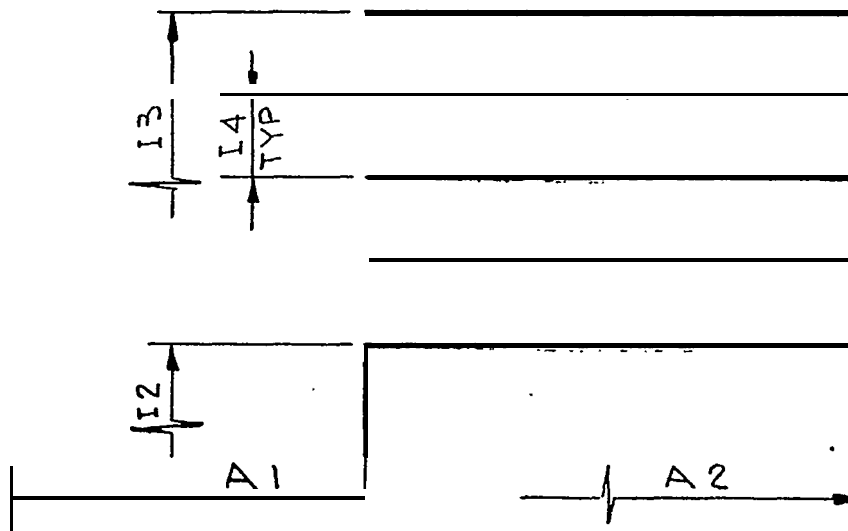
Distribution

DRA 300,I2,I3,I4(+A1+A2)

Q 6408

FIG. 1

(ROUT 350)



nwmW1

- I2 MIN DISTANCE IN Y DIRECTION
- I3 MAX DISTANCE IN V DIRECTION
- I4 INCREMENTAL DISTANCE
- A1 MIN DISTANCE IN X DIRECTION
- A2 MAX DISTANCE IN X DIRECTION

EXAMPLE DRA 301,+6F,+12F,+2F(+7F+8F)

DRA 301,I2,I3,I4(+A1+A2)

Q 6408

FIG. 2

(RCHT 351)

Figure 3. DRA 302 & DRA 305: DRA 302 and 305 create solid vertical and horizontal lines intersecting a frame contour called from the data base. The use of entering arguments is similar to the previous DRA s.

Figure 4. DRA 303 & DRA 306: DRA 303 and 306 generate a parallel at a distance A2 from a frame contour called from the data base and generate a series of solid vertical or horizontal lines from given points which terminate at the parallel contour.

Figure 5. DRA 325, DRA 326, DRA 327 and DRA 331: The solid line DRA's were recreated to provide dashed lines in place of the solid.

DRA 325 - Dashed vertical lines

DRA 326 - Dashed horizontal lines

DRA 327 - Dashed vertical lines intersecting a frame contour

DRA 331 - Dashed horizontal line intersecting a parallel to a frame contour

Figure 6. DRA 350, DRA 351, DRA 352 and DRA 354: The previous series is repeated for the line pattern which traditionally represents bulkheads intersecting the far side of the plate viewed. The arguments now include a parameter for the thickness of the line. Thicknesses appropriate for various scales are listed. The sign of this argument acts as a flag to test the location of the molded line, i. e., in DRA 350 + A3 places the ML to the right - A3 places the ML to the left.

Figure 7. DRA 375, DRA 376, DRA 377 and DRA 379: The series is again repeated using the symbols for butt and seam lines.

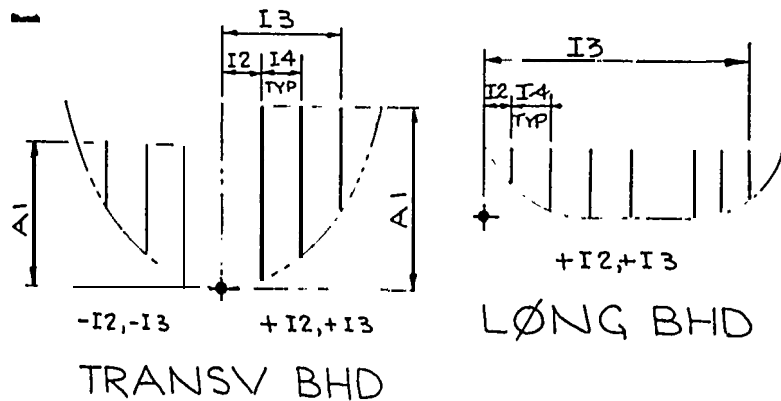
The various line types are arranged in a numbered series.

DRA 300 to 324 Solid Line

DRA 325 to 349 Dashed Line

DRA 350 to 375 Bulkhead - Far Side

DRA 375 to 399 Butts and Seams



Parameters
 I2 MIN DISTANCE IN X DIRECTION
 I3 MAX DISTANCE IN X DIRECTION
 I4 INCREMENTAL DISTANCE
 A1 HEIGHT ABV Φ

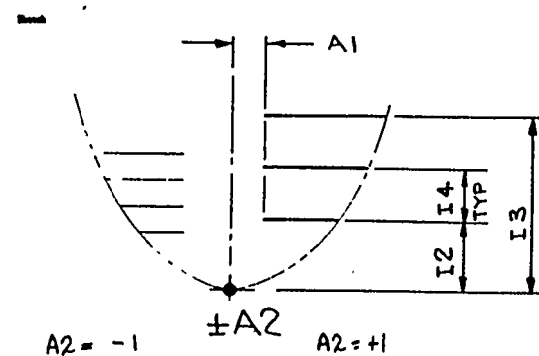
Comments

EXAMPLE DRA 302,+GF,+18F,+GF(+27F)
 DRA 302,-GF,-18F,+GF(+20F)

AUTOKON S. ENDRIS G. QUINCY
 Usage DRAFTING
 Distribution — DRA 302,I2,I3,I4(+A1)

Q 6408

(ROUT 340)



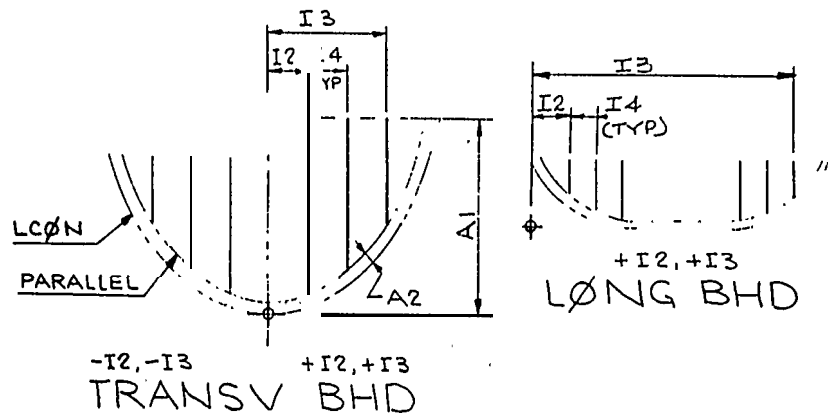
Parameters
 LKG FWD
 I2 MIN DISTANCE IN Y DIRECTION
 I3 MAX DISTANCE IN Y DIRECTION
 I4 INCREMENTAL DISTANCE
 A1 DISTANCE OFF Φ
 A2 +1,-1

EXAMPLE DRA 305,+20F,+40F,+10F(+GF+1)
 DRA 305,+18F,+30F,+GF(-8F-1)

AUTOKON S. ENDRIS G. QUINCY 8-15-12
 Usage
 Distribution — DRA 305,I2,I3,I4(+A1 \pm A2)

Q 6408

(ROUT 347,368)



Parameters
 I2 MIN DISTANCE IN X DIRECTION
 I3 MAX DISTANCE IN X DIRECTION
 I4 INCREMENTAL DISTANCE
 A1 HEIGHT ABV ϕ
 A2 DISTANCE TO PARALLEL

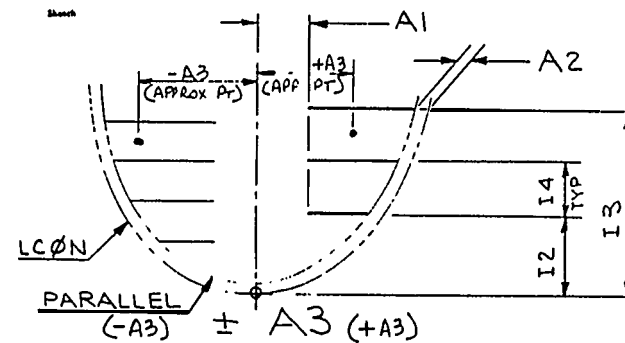
Comments

EXAMPLE DRA 303, +6F, +18F, +6F (+27F + 18I)
 DRA 303, -6F, -18F, +6F (+27F + 2F)

AUTOKON	Control by	Company	Date
	S. ENDRIS	G.D. QUINCY	8-15-72
	Usage	DRAFTING	
Distribution	DRA 303, I2, I3, I4 (+A1 + A2)		

Q 6408

(ROUT 306, 378)



Parameters
 I2 MIN DISTANCE IN Y DIRECTION
 I3 MAX DISTANCE IN Y DIRECTION
 I4 INCREMENTAL DISTANCE
 A1 DISTANCE OFF ϕ
 A2 DISTANCE TO PARALLEL
 A3 "A CORRECTION" OR "A CORRECTION"

Comments

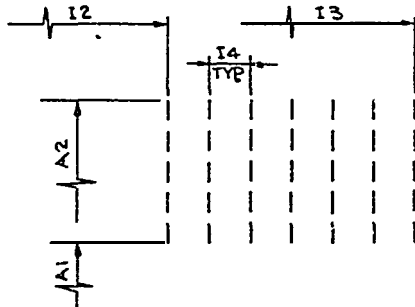
EXAMPLE DRA 306, +10F, +30F, +15F (+16F + 2F + 1)
 DRA 306, +8F, +23F, +15F (-15F + 18I - 2BI)

AUTOKON	Control by	Company	Date
	S. ENDRIS	G.D. QUINCY	8-15-72
	Usage	DRAFTING	
Distribution	DRA 306, I2, I3, I4 (+A1 + A2 \pm A3)		

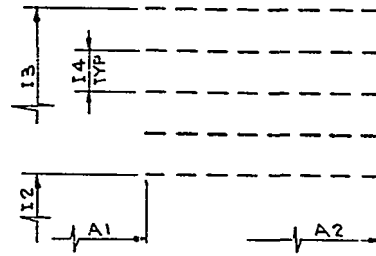
Q 6408

(ROUT 374)

FIG. 4



- I2 MIN DISTANCE IN X DIRECTION
- I3 MAX DISTANCE IN X DIRECTION
- I4 INCREMENTAL DISTANCE
- A1 MIN DISTANCE IN Y DIRECTION
- A2 MAX DISTANCE IN Y DIRECTION



- I2 MIN DISTANCE IN Y DIRECTION
- I3 MAX DISTANCE IN Y DIRECTION
- I4 INCREMENTAL DISTANCE
- A1 MIN DISTANCE IN X DIRECTION
- A2 MAX DISTANCE IN X DIRECTION

EXAMPLE DRA 325, +GF, +12FGI, +GI (+GF + 12FGI)
DRA 325, -GF, -12FGI, -GI (-GF - 12FGI)

AUTOKON	Drawn by	S. ENDRIS	Checked by	G. QUINCY	Date	8-15-72
	DRAFTING					
DRA 325, I2, I3, I4 (+A1 + A2)						

Q 4408

(ROUT 352)

EXAMPLE DRA 326, +GF, +12F, +2F (+7F + 8F)

AUTOKON	Drawn by	S. ENDRIS	Checked by	G. QUINCY	Date	8-15-72
	DRAFTING					
DRA 326, I2, I3, I4 (+A1 + A2)						

Q 4408

(ROUT 353)

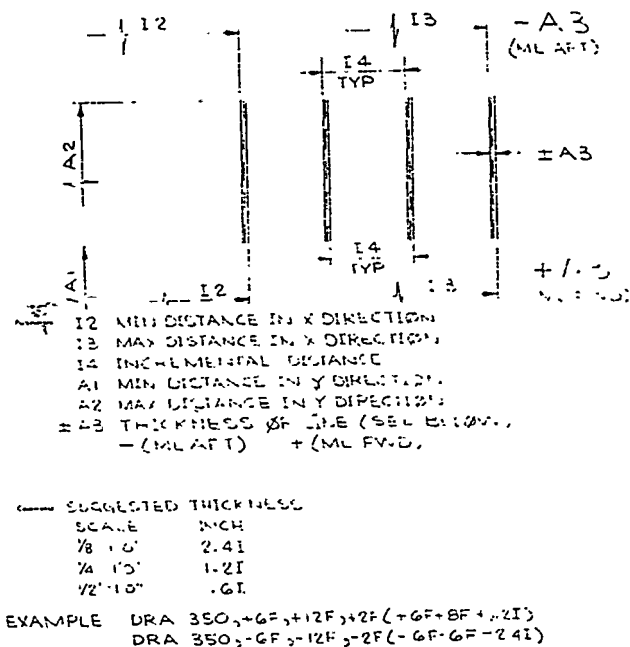
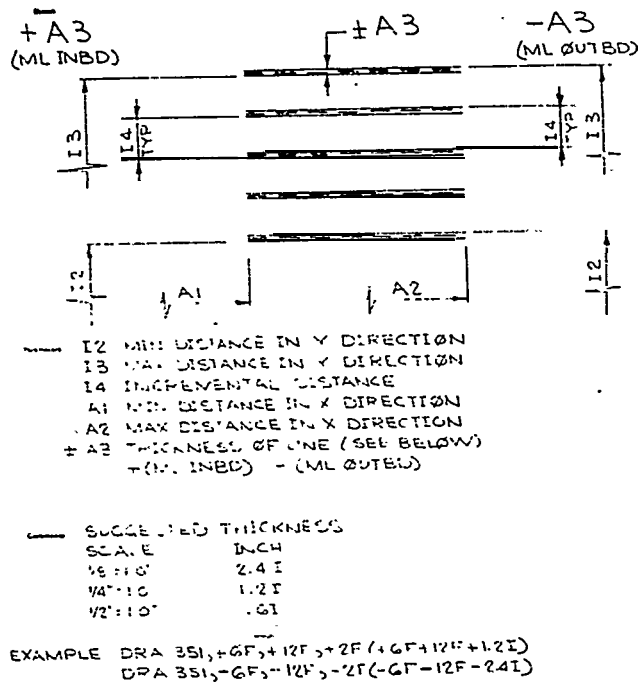
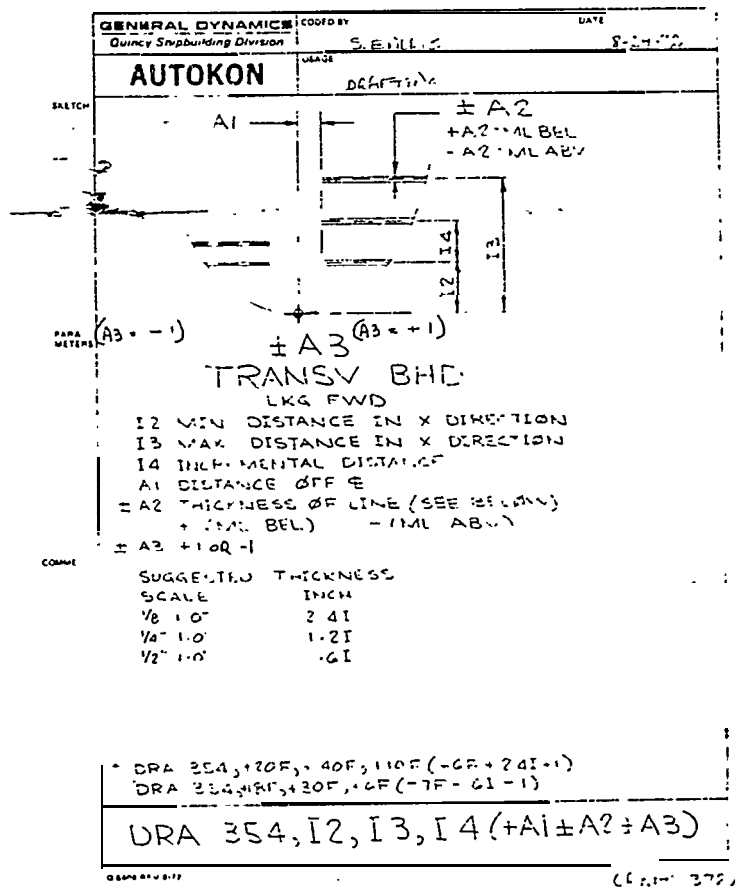
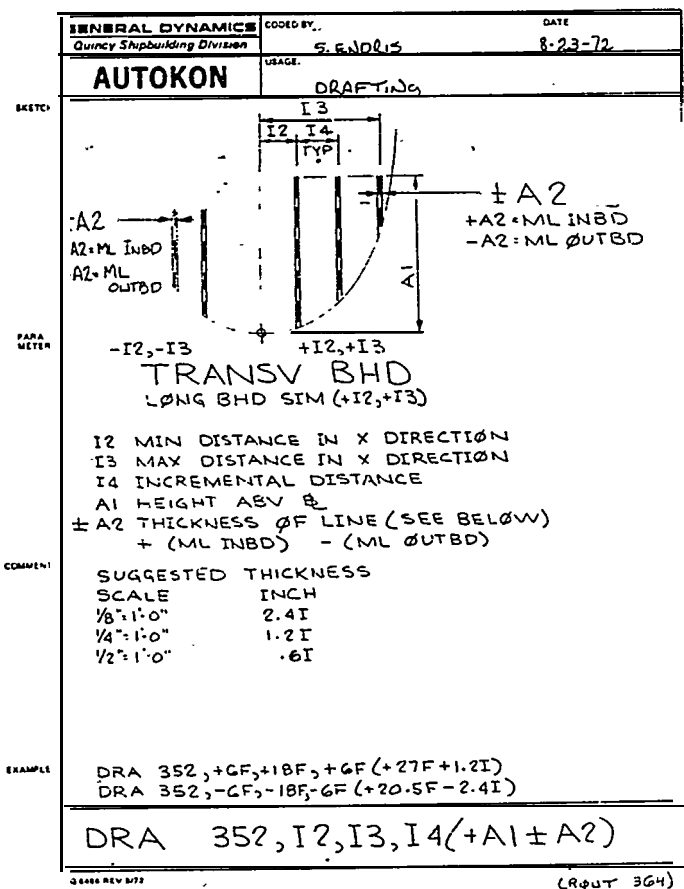
GENERAL DYNAMICS Quincy Shipbuilding Division		Drawn by	S. ENDRIS	Checked by		Date	8-19-72
AUTOKON		DRAFTING					
SKETCH							
APP. METERS	<p>TRANSV BHD LKG FWD</p> <p>I2 MIN DISTANCE IN Y DIRECTION I3 MAX DISTANCE IN Y DIRECTION I4 INCREMENTAL DISTANCE A1 DISTANCE OFF \perp A2 DISTANCE TO PARALLEL A3 "+ APPROX COOR." "- APPROX COORDINATE"</p>						
EXAMPLES	<p>DRA 331, +10F, +30F, +10F (+10F + 27F)</p> <p>DRA 331, +8F, +23F, -51 (-15F + 181 - 1)</p> <p>DRA 331, I2, I3, I4 (+A1 + A2 \pm A3)</p>						

GENERAL DYNAMICS Quincy Shipbuilding Division		Drawn by	S. ENDRIS	Checked by		Date	8-15-72
AUTOKON		DRAFTING					
SKETCH							
APP. METERS	<p>LONG BHD TRANSV BHD</p> <p>I2 MIN DISTANCE IN X DIRECTION I3 MAX DISTANCE IN X DIRECTION I4 INCREMENTAL DISTANCE A1 HEIGHT ABV \perp</p>						
EXAMPLES	<p>DRA 327, +GF, +18F, +GF (+27F)</p> <p>DRA 327, -GF, -18F, +GF (+20F)</p> <p>DRA 327, I2, I3, I4 (+A1)</p>						

Q 4408 REV 0/12

(ROUT 348)

FIG. 5



AUTOKON CODED BY: S. ENDRIS CHECKED BY: G. QUINCY DATE: 8-23-72
DRAFTING

DRA 351, I2, I3, I4 (+A1+A2 \pm A3)

344

(ROUT 373)

Q 6408

AUTOKON CODED BY: S. ENDRIS CHECKED BY: G. QUINCY DATE: 8-23-72
DRAFTING

DRA 350, I2, I3, I4 (+A1+A2 \pm A3)

(ROUT 383)

Q 6408

FIG. 6

GENERAL DYNAMICS		CODED BY:	DATE
Guincy Shipbuilding Division		S. ENDRIS	9-7-72
AUTOKON		USAGE:	DRAFTING

-1 ±A3 +1
TRANSV BHD

I2 MIN DISTANCE IN X DIRECTION
I3 MAX DISTANCE IN X DIRECTION
I4 INCREMENTAL DISTANCE
A1 DISTANCE OFF E (±)
A2 DISTANCE TO SYMBOL
±A3 +1 OR -1

EXAMPLE
DRA 379, +30F, +50F, +10F (+7F +3F +1)
DRA 379, +25F, +32F, +7F (+12F +12F -1)

DRA 379, I2, I3, I4 (±A1 + A2 ±A3)

GENERAL DYNAMICS		CODED BY:	DATE
Guincy Shipbuilding Division		S. ENDRIS	9-6-72
AUTOKON		USAGE:	DRAFTING

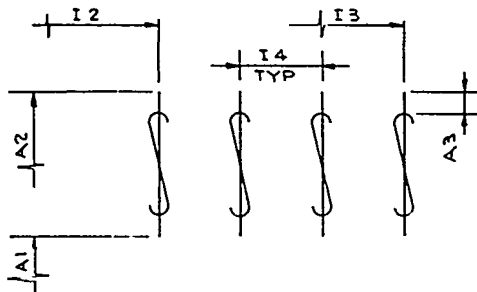
-I2, -I3 +I2, +I3
TRANSV BHD
LØNG BHD SIM (+I2 + I3)

I2 MIN DISTANCE IN X DIRECTION
I3 MAX DISTANCE IN X DIRECTION
I4 INCREMENTAL DISTANCE
A1 HEIGHT ABV E
A2 DISTANCE TO SYMBOL

EXAMPLE
DRA 377, +10F, +18F, +8F (+36F +4F)
DRA 377, -12F, -18F, -6F (+30F +3F)

DRA 377, I2, I3, I4 (+A1 + A2)

(R057 356)

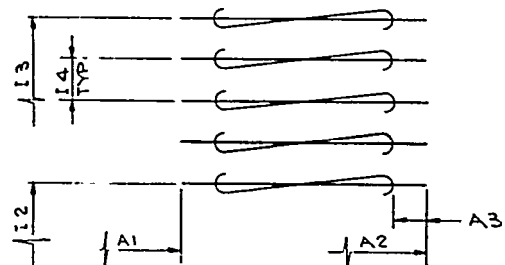


I2 MIN DISTANCE IN X DIRECTION
I3 MAX DISTANCE IN X DIRECTION
I4 INCREMENTAL DISTANCE
A1 MIN DISTANCE IN Y DIRECTION
A2 MAX DISTANCE IN Y DIRECTION
A3 DISTANCE TO BUTT SYMBOL

EXAMPLE DRA 375, +6F, +12F, +3F (+6F +12F +9F)
DRA 375, -6F, -12F, -3F (-6F -12F -9F)

AUTOKON		CODED BY:	DATE
S. ENDRIS		GP QUINCY	9-5-72
DRAFTING			
DRA 375, I2, I3, I4 (+A1 + A2 + A3)			

Q 6408



I2 MIN DISTANCE IN Y DIRECTION
I3 MAX DISTANCE IN Y DIRECTION
I4 INCREMENTAL DISTANCE
A1 MIN DISTANCE IN X DIRECTION
A2 MAX DISTANCE IN X DIRECTION
A3 DISTANCE TO BUTT SYMBOL

EXAMPLE DRA 376, +6F, +12F, +2F (+6F +12F +1F)
DRA 376, -6F, -12F, -2F (-6F -12F -1F)

AUTOKON		CODED BY:	DATE
S. ENDRIS		GP QUINCY	9-5-72
DRAFTING			
DRA 376, I2, I3, I4 (+A1 + A2 + A3)			

Q 6408

FIG 7

Figure 8. DRA 312: DRA 312 is typical of another solid line DRA. In this macro a parallel to a frame contour is generated to simulate a web frame.

A1 - represents the depth of a web frame.

A2 and A4 - approximate values which place the parallel in the proper quadrant.

A3 and A5 - actual deck heights.

Figure 9. DRA 401: This DRA was developed to draw a series of angles representing stiffeners under a deck or on a longitudinal bulkhead. A “DO LOOP” is again used to define the start and end of the series of angles.

A1 and A2 - set a new origin.

A3 - rotates the axis of the draw and allows the series of stiffeners to be drawn at any angle.

A4 thru A6 - arguments for the sizes of the stiffeners.

Figure 10. DRA 404: DRA 404 is similar to 401 but draws Tee stiffeners. -

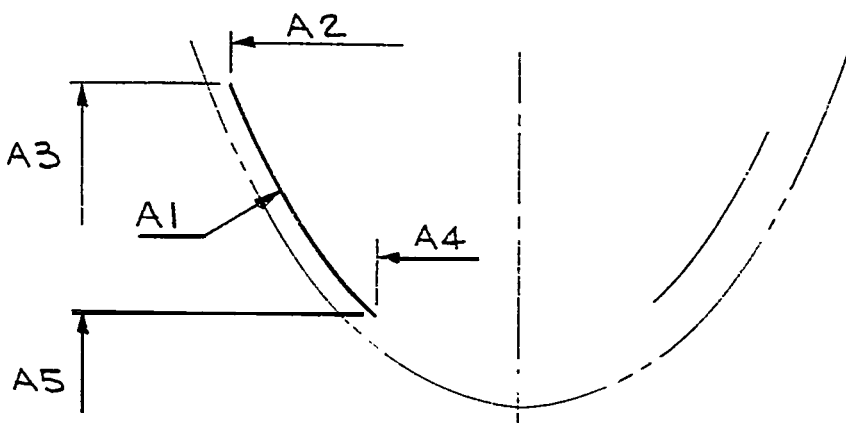
“Figure 11. DRA 412 and 413: DRA 412 and 413 will draw a series of access openings or lightening holes either horizontally or vertically.

The DRA’s described above represent the fundamental building blocks of the method. These basic DRA’s may be used independently within the coding language or may be boot-strapped into more elaborate macros.

Figure 12. DRA 654: This DR represents the basic configuration of a typical Quincy LNG Tanker bow web frame. It was coded using the

GENERAL DYNAMICS <i>Quincy Shipbuilding Division</i>	CODED BY: RV/ KUCHARSKI	DATE 2-26-73
AUTOKON	USAGE: DRAFTING	

SKETCH



PARAMETERS

A1 DISTANCE TO PARALLEL
 A2 APPROXIMATE X COORDINATE
 A3 ACTUAL Y COORDINATE
 A4 APPROXIMATE X COORDINATE
 A5 ACTUAL Y COORDINATE

COMMENT

EXAMPLES

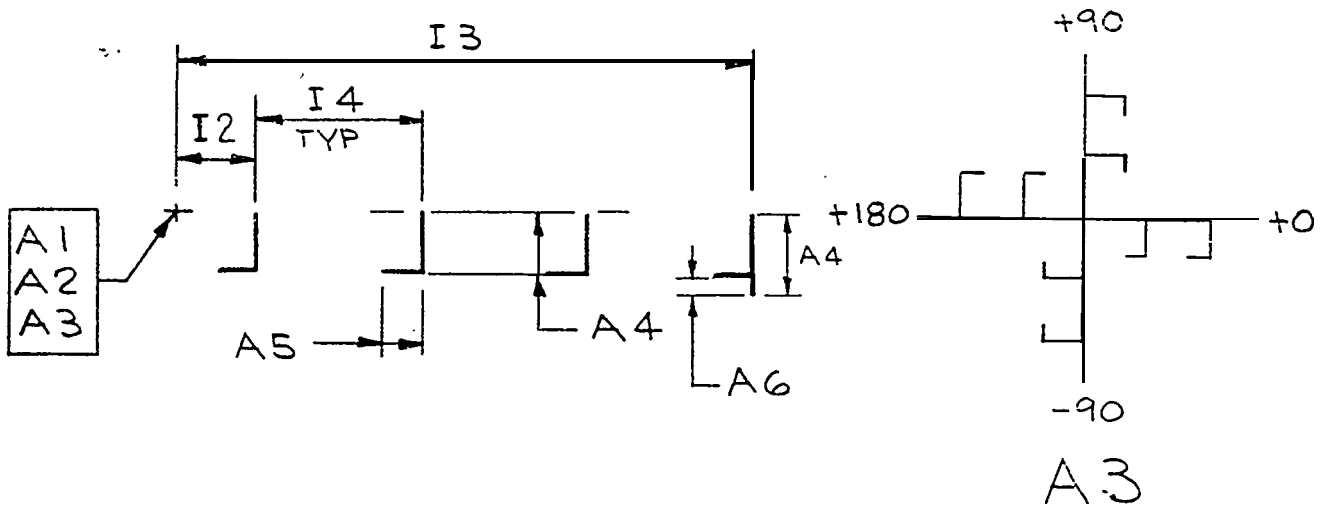
DRA 312 (+1F-60F+50F-30F+20F)
 DRA 312 (+2F+60F+50F+30F+20F)

DRA 312(±A1±A2+A3±A4+A5)

Q 6408 RFV 8/72

FIG. 8

Sketch



Parameters

- I2 DISTANCE TO FIRST STIFFENER
- I3 DISTANCE TO LAST STIFFENER
- I4 INCREMENTAL DISTANCE
- A1 X COORDINATE
- A2 Y COORDINATE
- A3 DIRECTION
- A4 DEPTH OF WEB
- A5 WIDTH OF FLANGE
- A6 DISTANCE TO FLANGE

Comments

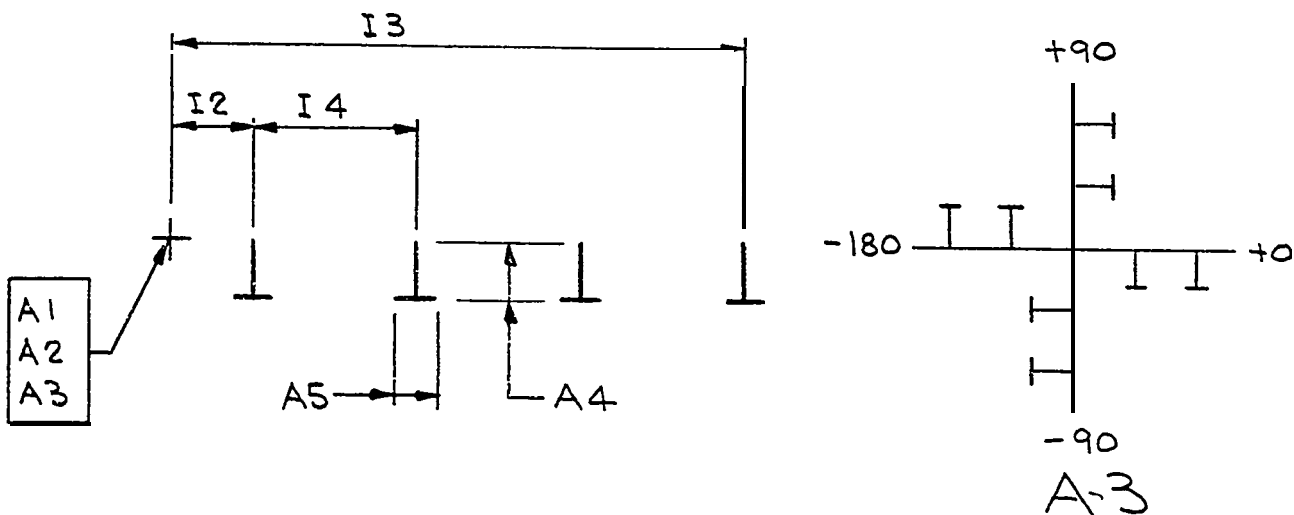
EXAMPLE DRA 401,+0,+6F,+2F(+7F+14F-90+6I+4I-0)
 DRA 401,+2F,+6F,+2F(+7F+14F+180+6I+4I+16)

AUTOKON	Coded by	Company	Date
	S. ENDRIS	GD QUINCY	9-6-72
	Usage	DRAFTING	
Distribution	DRA 401,I2,I3,I4(+A1---+A6)		

Q 6408

FIG. 9

Sketch



Parameters
 I2 DISTANCE TO FIRST STIFFENER
 I3 DISTANCE TO LAST STIFFENER
 I4 INCREMENTAL DISTANCE
 A1 X COORDINATE
 A2 Y COORDINATE
 A3 DIRECTION
 A4 DEPTH OF WEB
 A5 WIDTH OF FLANGE

Comments

EXAMPLE DRA 404,+0,+6F,+2F(+7F+14F-90+6I+4I)
 DRA 404,+2F,+6F,+2F(+7F+14F+90+6I+4I)

AUTOKON	Created by	Company	Date
	S. ENDRIS	GD QUINCY	9-6-72
	Usage	DRAFTING	
Distribution	DRA 404,I2,I3,I4(+A1---+A5)		

Q 6408

FIG. 10

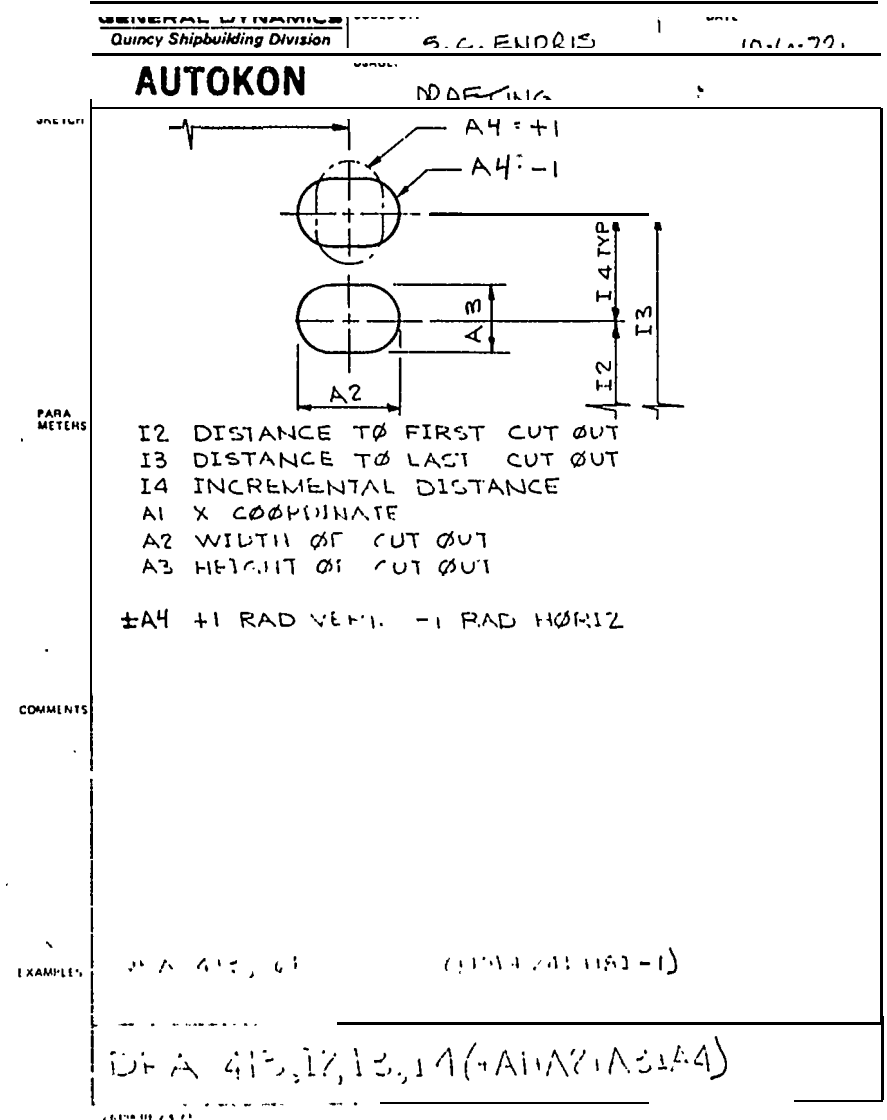
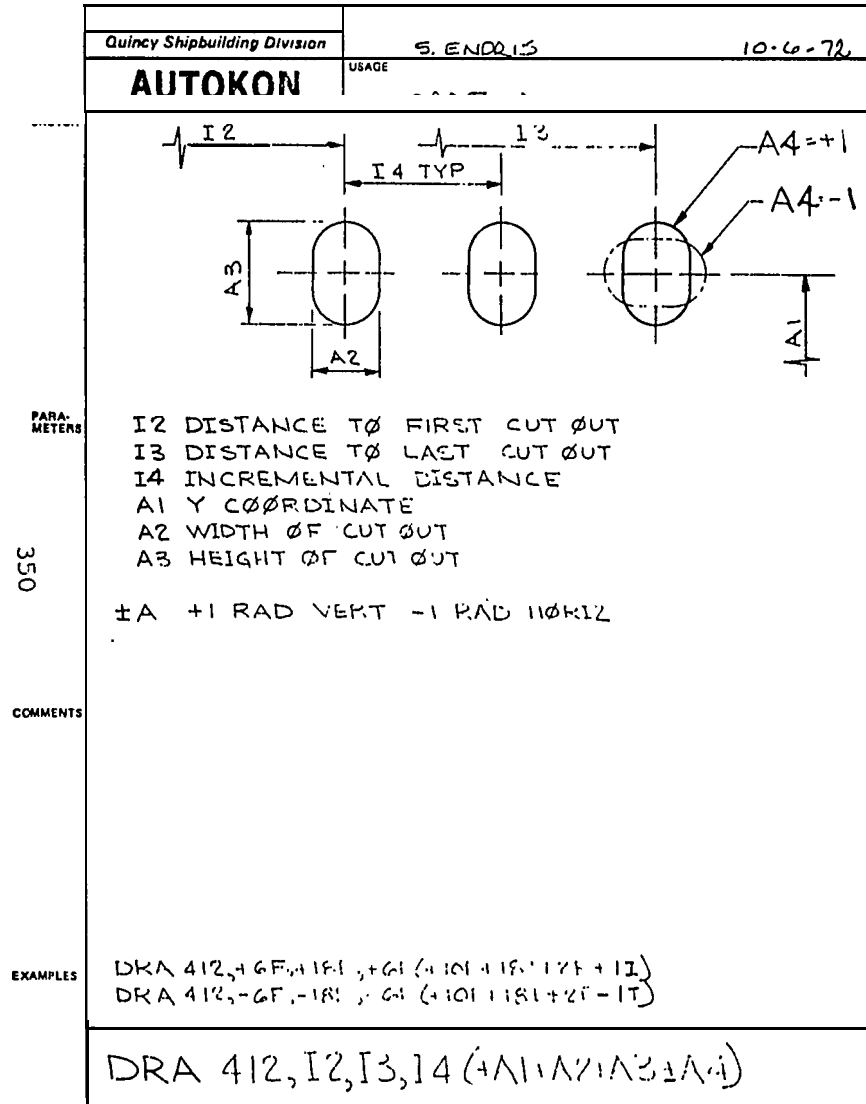
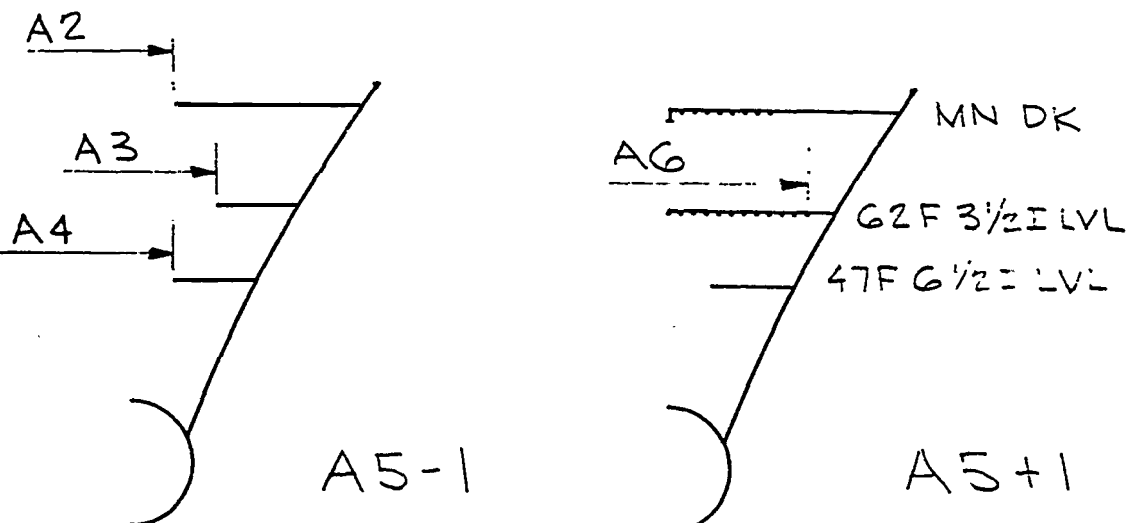


FIG. 11

AUTOKON

USAGE:
DRAFTING

SKETCH



PARAMETER

- A1 FR NØ
- A2 DIST TO MN DK
- A3 DIST TO 62F 3 1/2 I LVL
- A4 DIST TO 47F 6 1/2 I LVL
- A5 -1 WITHOUT DECK STIFFS
+1 WITH DECK STIFFS
- A6 DIST TO LAST STIFF

COMMENT

EXAMPLES

DRA 654 (+125 + 50I + 100I + 50I - 1)
DRA 654 (+125 + + + +1 + 523I)

DRA 654 (+A1 + A2 + A3 + A4 ± A5 + A6)

system language and makes several calls of basic drafting (DRA) macros. The deck heights are constant and included in the coding.

A1 - identifies the specific frame to be retrieved from the database.
A2, A3 and A4 - are the distances from the ship's centerline to the decks or flats.

A5 - a flag to indicate if underdeck stiffeners are to be included as part of the drawing.

A6 - the distance to the most outboard stiffener on the flat located 62 ft. above baseline. This value is omitted when stiffeners are not indicated. This DRA is the first macro called when coding each of the five specific web frames of this type in the LNG bow section.

APPLICATION OF DRA'S

Drafting macros, together with other subroutines and stored ship hull geometry, provide the capability of describing large amounts of graphic data which can be stored in the data base and drawn by an N/C plotter.

Figure 13. Web Frame 133: The figure contains a listing of the manuscript and the resulting drawing of a major structural system of the LNG tankers now being constructed at Quincy. An explanation of the coding follows:

<u>Line/s</u>	<u>Remarks</u>
1	Identification number
2-3	Various program options
4-6	General comments
7	Startpoint: This will establish an "X-Y" coordinate system about the ships base line, center line. A COMM statement provides manuscript annotation.

1. PC 1021330
2. \$A1.0
3. \$K1.0
4. COMM (RWB LUG TRANSV WEB FR 33 STD SIDE LUG FWD
5. THIS PROGRAM OFVER (OVER) FROM PLAN 401-211-12
6. REV C ON 10/10/73)
7. SPT
8. DRA 554 (+133+++1+300 COMM (BL/CL)
9. DRA 434,265116 ,2671 ,7F (+192F++25112+12116)
10. DRA 401,2951 ,4441 ,29.51(+192F++61+41+)
11. H1=(+192F-25112+1)
12. DRA 306,81 ,=(H1+11),24 (-61+181+4001
13. DRA 305,22F9116 ,3212146,24 (+11)
14. COMM (FR WEB
15. DRA 312 (+31114+4001+H1+2671+62F3140)
16. DRA 312 (+31114+4001+H1+2671+62F3140)
17. ROUT 339(+21F4110)
18. CIR:CTR (+12F) RAD (-9F4118)
19. CPT (+2F7114)
20. ROUT 339(+2F4114)
21. C R:CTR (+12F) RAD (+9F3118)
22. CPT (+21F3114)
23. H2=(29.51) COMM (STIFF SP)
24. COMM (BHD STIFFS)
25. DRA 300,0 ,301 ,82 (+24F+62F3116)
26. DRA 300,531 ,601 ,82 (+23F61+52F3115)
27. DRA 300,98.5 ,901 ,52 (+22F21+62F3116)
28. DRA 303,1191 ,1951 ,82 (+62F3116+151)
29. COMM (AD)
30. H3=(+62F3116-29.51) H4=(+62F3116-99.51)
31. H5=(+62F3116-147.51) H6=(+62F3116-29.51)
32. H7=(+62F3116-48.51) H8=(+62F3116-147.51)
33. H9=(+62F3116-29.51) H10=(+591+14.751)
34. DRA 412,810 ,2351 ,82 (+83+181+301+1)
35. DRA 412,810 ,2361 ,82 (+84+181+301+1)
36. DRA 412,810 ,2061 ,82 (+85+181+301+1)
37. DRA 412,810 ,1771 ,52 (+86+181+301+1)
38. DRA 412,810 ,1471 ,82 (+87+181+301+1)
39. DRA 412,810 ,1471 ,82 (+88+181+301+1)
40. DRA 412,810 ,1131 ,82 (+89+181+301+1)
41. COMM (STANCHIONS)
42. DRA 350,612 ,71 ,7F (+88150+124F-31146)+1214)
43. DRA 350,61 ,71 ,7F (+62F3140+H1+121)
44. DRA 350,271116 ,2721 ,7F (+62F3140+H1+121)
45. DRA 346 (+182F++86F)
46. COMM (DK BUTTS)
47. DRA 382,44,251 ,3991 ,88.51(+192F3124+61)
48. DRA 382,44,251 ,2221 ,88.51(+192F3140+61)
49. OFF CT SL:EP1 ON CT
50. CN PAUSE
51. TEXT ,+5F ,+6F ,+1F(TRANSV NT BHD / WEB FR 33
52. TEXT ,+13F91 ,+7F61 ,+51(STD SIDE LUG FWD)
53. TEXT ,+61 ,+87F ,+61(CL OF SHIP)
54. ESS1 (.3. RWK SPTLL PC 1021330 .4.)
55. SCALF(.312495
56. FIN
57. #
MANUS 0 1021 0 LINE 0 COMM 101
MANUS 1 1021 *** LINE 57 COMM 101

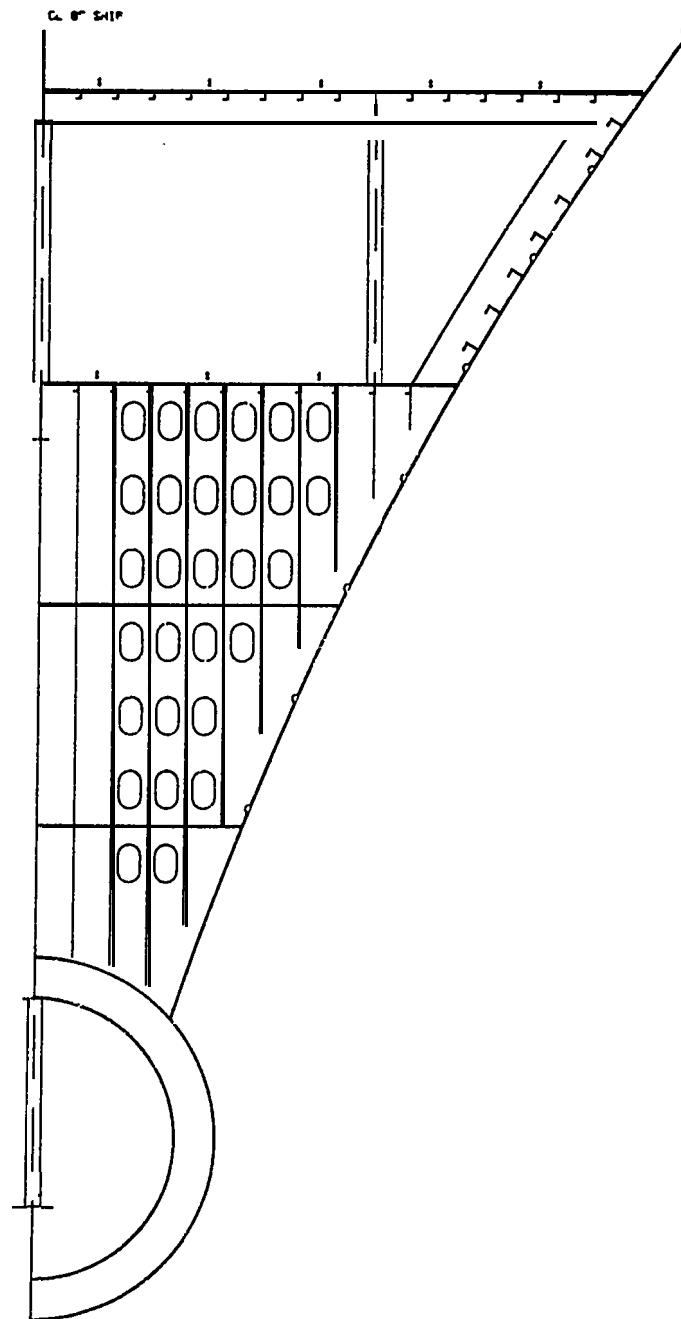


FIG. 13

TRANSV NT BHD / WEB FR 33
STD SIDE LUG FWD

<u>Line/s</u>	<u>Remarks</u>
8	DRA 654: Calls the DRA described in Figure 12. A1 - FR 133 A2 thru A4 are the distances from the centerline to the various decks A5 is positive so stiffeners are plotted. A6 represents the distance to last stiffener
9-10	DRA 404 & 401 plot additional stiffeners
11	Value to be recorded in a table designated "B"
12	DRA 306 plots main deck girder
13	DRA 305 plots 32 ft-9-1/2-in. platform
14-16	Plots frame web
17-22	Plots bulb frame
23-24	Adds value to "B" table for bulkhead stiffener spacing.
25-28	DRA 300 & 303 plots bulkhead stiffeners.
29-33	Adds value to "B" table for access openings
34-40	DRA 412. Access openings
41-45	DRA 350 plots stanchions
46-48	DRA 382 plots deck butts
49	Pen up, return in a straight line to start point, pen down.
50	stop
51-53	Text: Will annotate the drawing
54	ESSI: Command to punch tape
55	Scale factor to scale drawing to 3/8" = 1' -0"
56	Fin: End of manuscript

The entire drawing is then stored in the data base. Once stored the drawing can be recalled whenever needed and drawn to whatever scale is required by varying the scale on the N/C Plotter. Often only a portion of the stored drawing is required for some specific purpose. To accommodate this need a "windowing" feature was incorporated into the system whereby only N/C data for that portion of a stored drawing within specific bounds is produced.

Figure 14. Windowing: this figure illustrates three windows called from the stored drawing of LNG Web Frame 113.

The input information is simply X rein, X max, Y rein, Y max.

The three views shown are:

- (a) Above the 62 ft. Flat
- (b) 62 ft, Flat and below to the bulb
- (c) The bulb

PLAN FORMATS

The structural plans for Quincy's most recent contracts were produced by construction unit, or block. That is, each plan contains all the data required to fabricate and assemble a specific building unit. A unit plan consists primarily of views of those portions of the major structural systems (shell, decks, webs, bulkheads, etc.) to be assembled as part of that unit. The use of the N/C drafting method described is particularly suited to this approach to plan preparation since each plan is made up of a series of partial views or windows of major structural systems.

Our approach is to use the N/C plotter to draw a series of windows of structural systems, as appropriate to a specific unit, on the original tracing medium. This "Plan Format" containing the basic views describing the structural configuration of the unit is given to the designer/draftsm to complete. In this way he does not spend his valuable time doing the tedious drafting of repetitive structural geometry and the laying out of frame lines and other hull contours. Instead he can concentrate on his special talents as a designer. The reduction in manual effort also allows more views to be included on a plan, thus increasing its clarity and the amount of information provided.

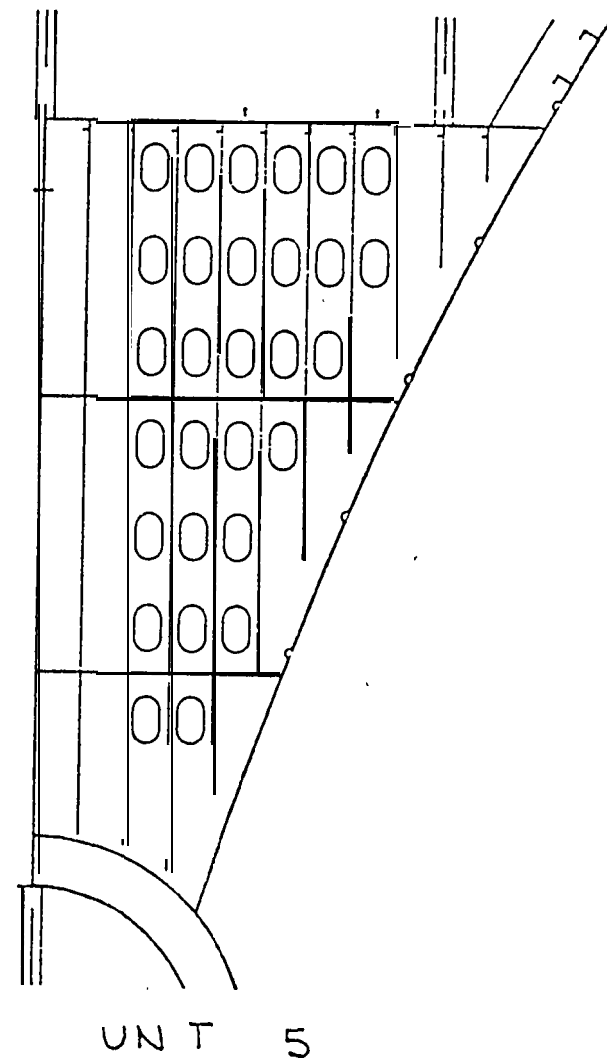
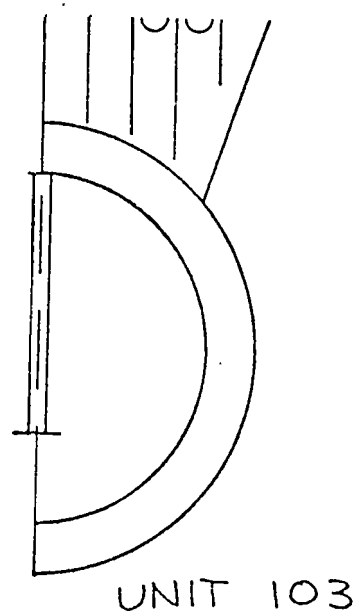
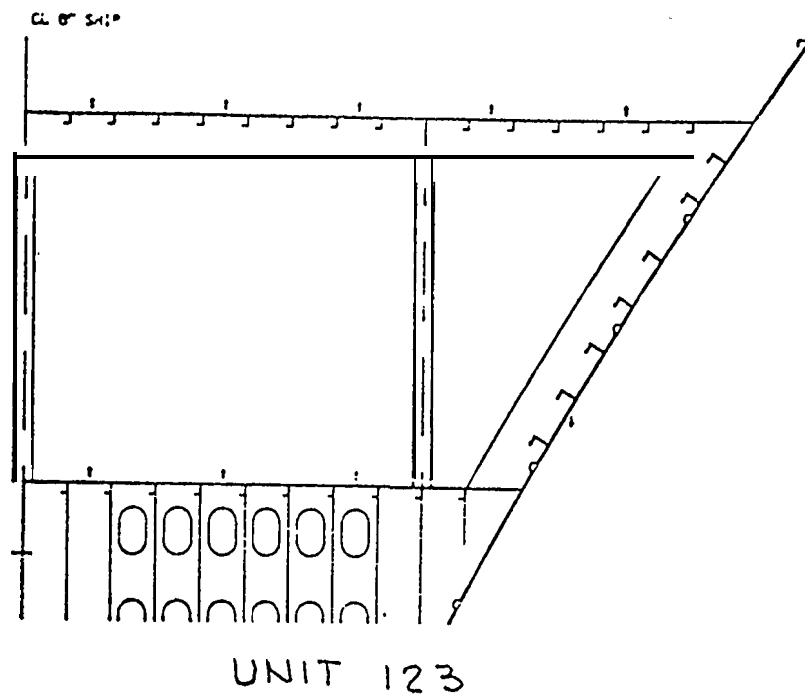


FIG. 14

Figure 14 shows three windows selected from one stored drawing. Each window is part of the Plan Format for a different structural unit plan. The AUTOKON system also allows for selecting a window from the stored shell expansion drawing. All windows can be drawn at any scale desired. We have used this method successfully in producing plans for the Liquefied Natural Gas tankers now under construction at Quincy.

Figure 15. Plan Format Specification: Plan Formats are created to specific instructions contained in a “Plan Format Specification” prepared for each plan. The positioning and scaling of each view is indicated requiring the overall arrangement of the plan to be thought out in advance by the designer/draftsman and approved by his supervisor. An area for estimating the savings in manual effort by preparation of the format is included to provide a means for identifying the savings realized.

Figure 16. Plan Format and Finished Plan: A Plan Format containing the series of windows related to a specific plan is shown together with the same plan as completed by the designer. The degree of assistance to the designer in relieving him of tedious repetitive detail is demonstrated.

While the method was developed primarily to assist in the production of structural unit plans, the concept also was applied to other types of plans. The method was particularly helpful in preparing structural backgrounds used for the machinery and distributive system composite drawings. Using the same structural system data developed for structural unit plans, entire web frames or machinery space flats were drawn on mylar at the enlarged scale required and the balance of the drawing added manually. This data was also used to provide formats showing the background structure for arrangement drawings. The extended capability of the Parts Program provided by the DRA routines also enabled us to provide specific graphical information upon request. Considerable time was saved by providing windows of structure drawn at the large scale required for preparing developmental sketches for

AUTOKON PLAN FORMAT SPECIFICATION

PLAN TITLE: UNIT 730 - 731

PLAN NO.: 401-383-09

PLAN SCALE: 3/8" CODED SCALE: _____

ADM SETTING: _____

VERIFIED: _____

DATE REQ'D.: _____

CHARGE NO.: 40212

TIME FOR MANUAL EQUIVALENT: _____

60

NOTES: SHEET # 1 of 2

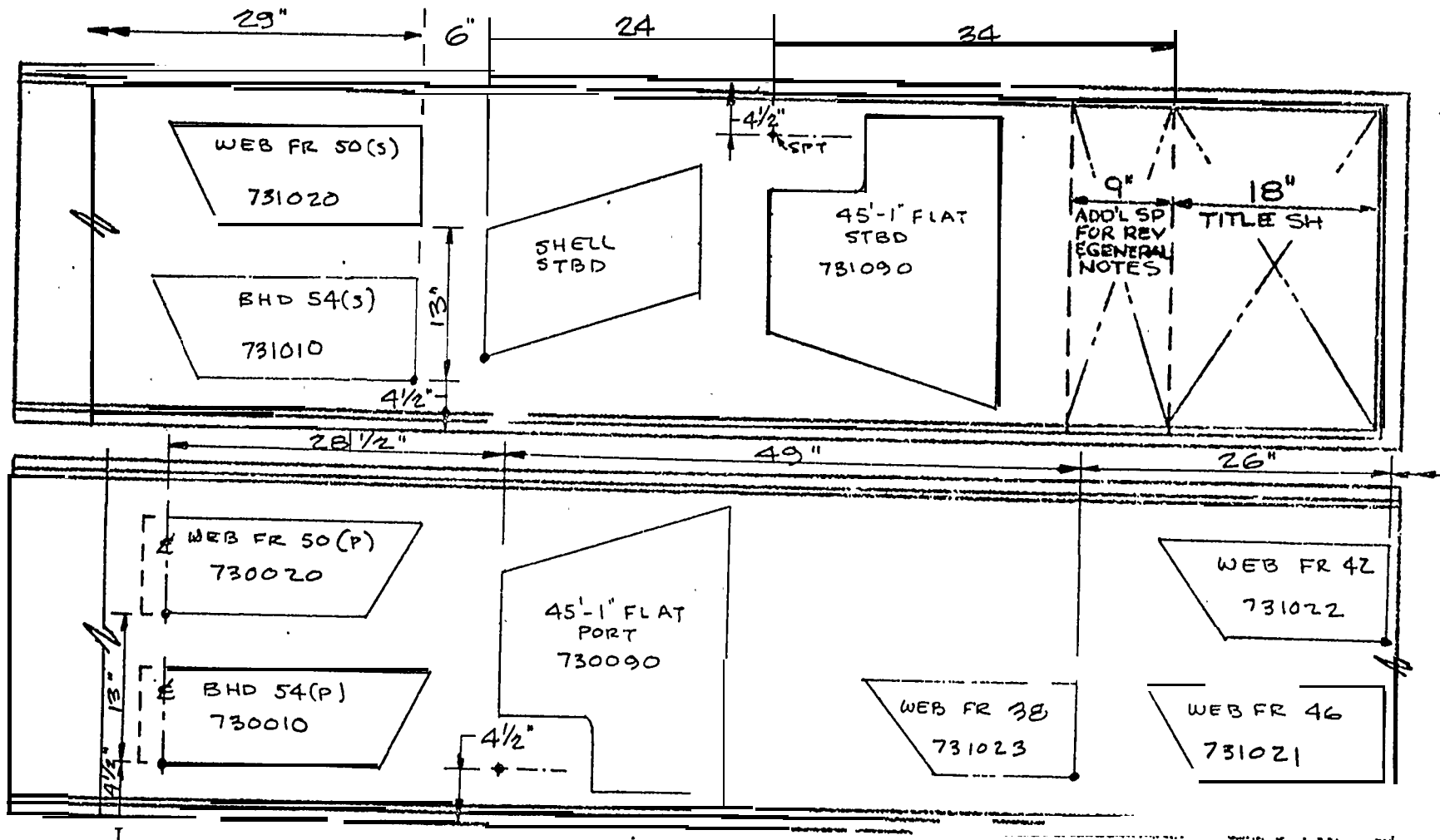
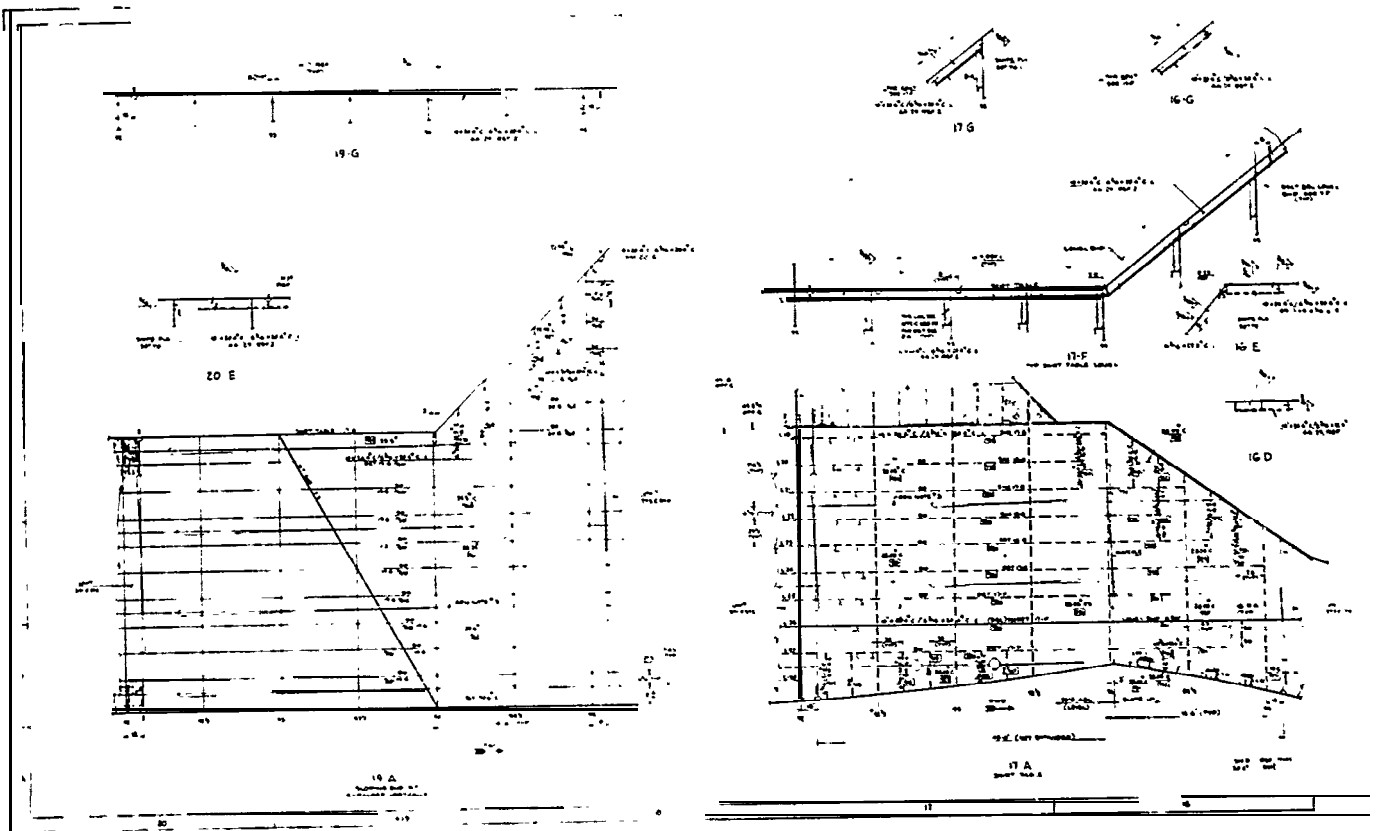
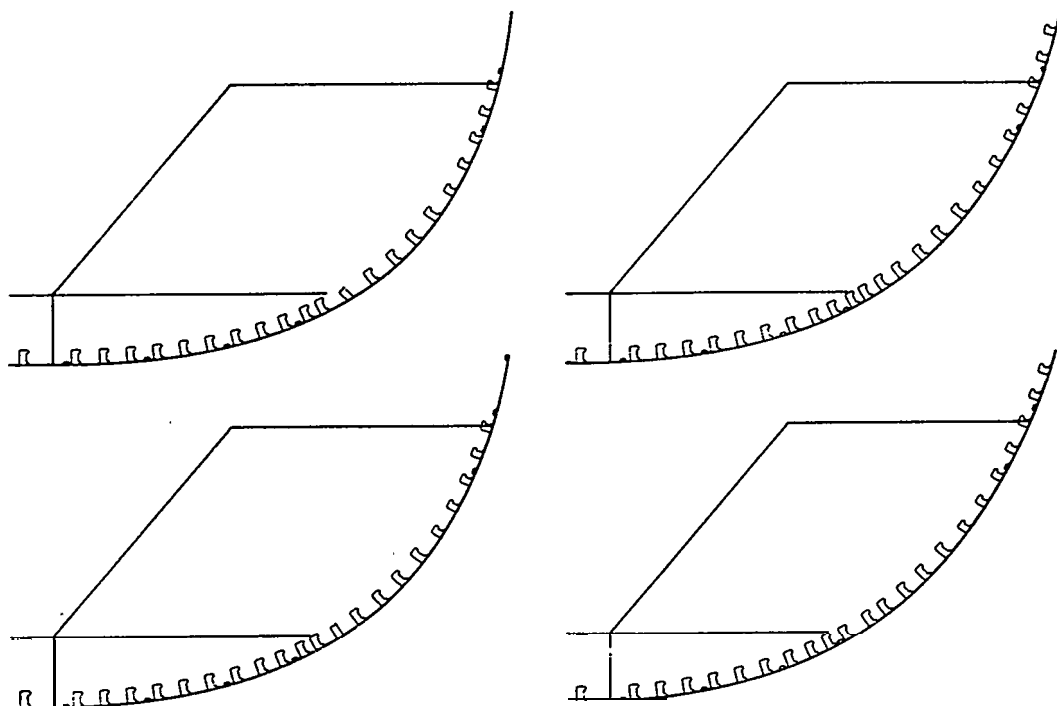
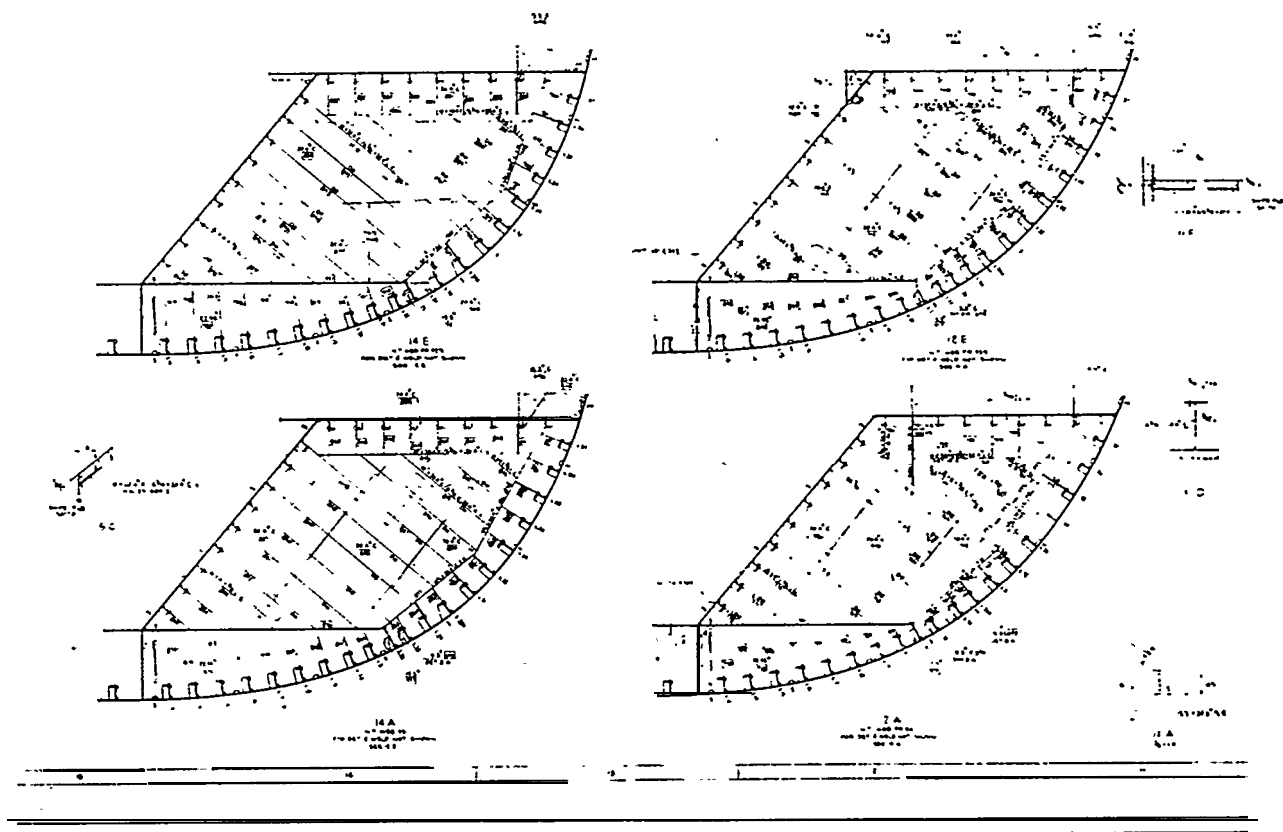


FIG.15





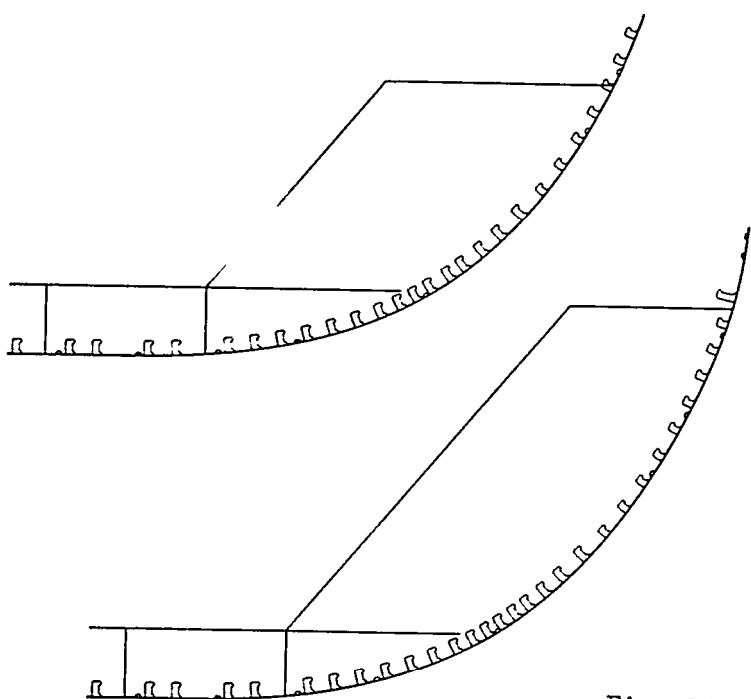
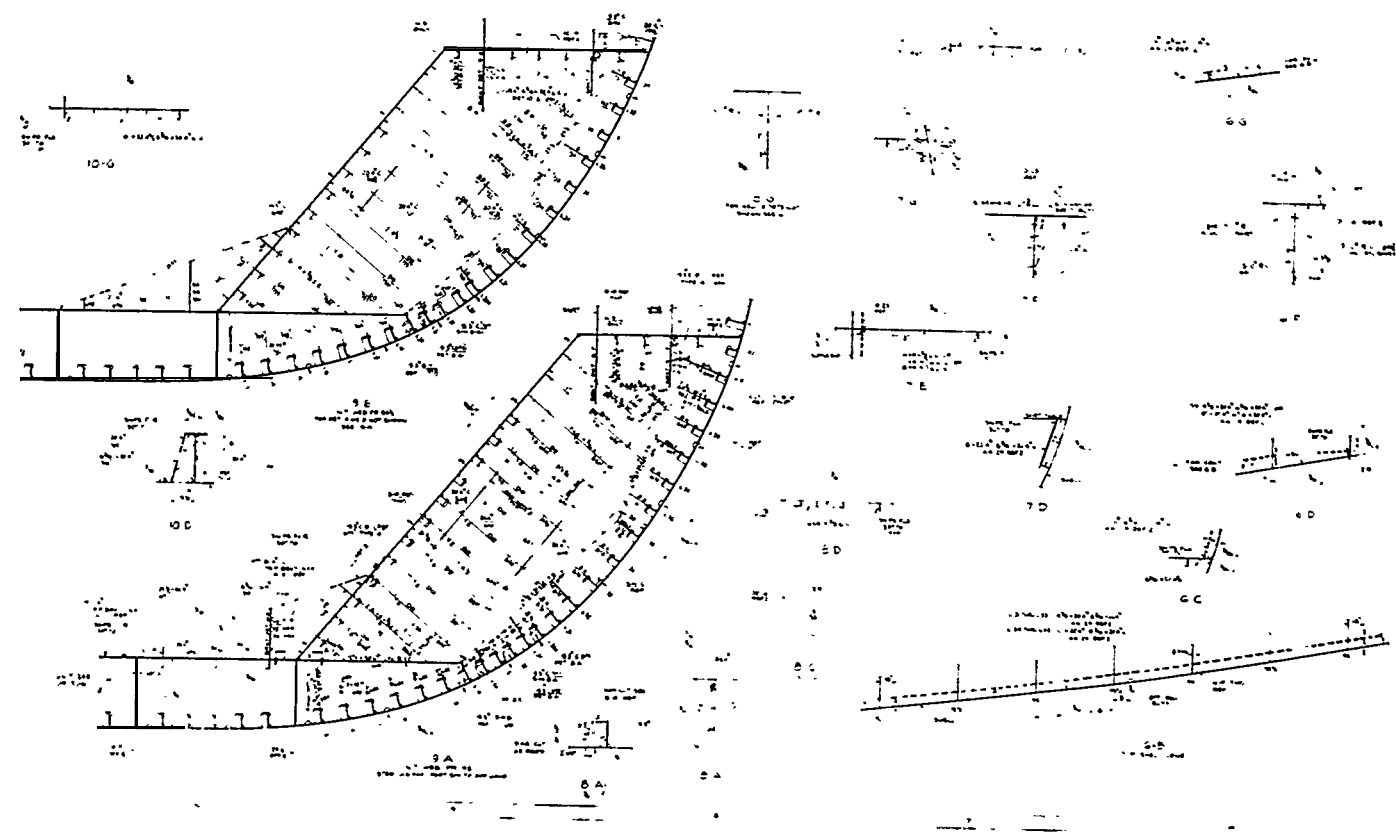
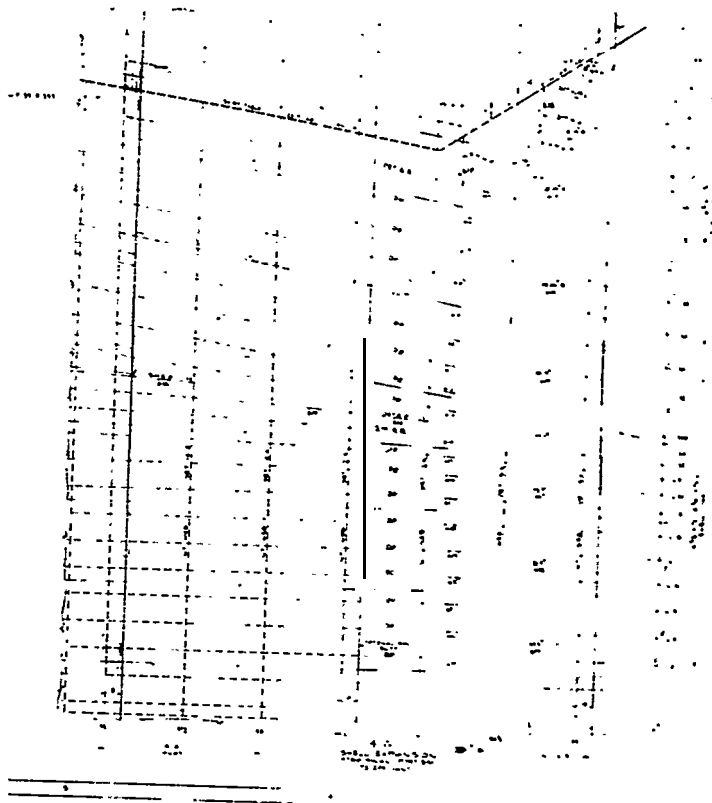


Fig. 16 (Cont'd)



GENERAL NOTES

1. This drawing is a perspective view of a rectangular structure, possibly a building or a container, with a grid pattern overlaid. The drawing is oriented diagonally.
2. The grid consists of solid and dashed lines forming a rectangular mesh.
3. A dashed line runs along the top edge of the structure.
4. The drawing is a technical drawing and should be used as such.
5. The drawing is a technical drawing and should be used as such.
6. The drawing is a technical drawing and should be used as such.
7. The drawing is a technical drawing and should be used as such.
8. The drawing is a technical drawing and should be used as such.
9. The drawing is a technical drawing and should be used as such.
10. The drawing is a technical drawing and should be used as such.

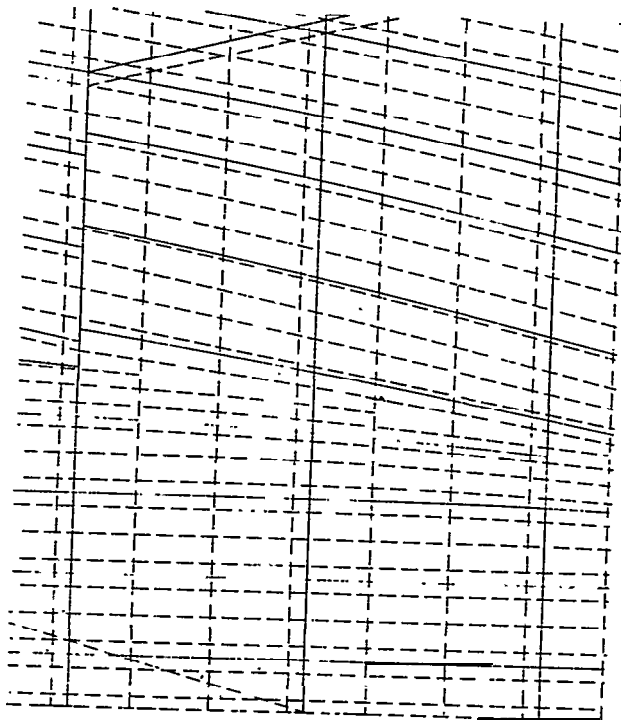


Fig. 16 (Cont'd)

such complex designing tasks as the main engine foundations and stern tube support structure. Savings were also realized using the DRA routines for non-structural applications such as the drawing of large tables for the plumbing fittings schedule. In this case, the task of drawing the many parallel lines required was performed by the N/C plotter.

Some Plan Formats, such as those for the Lines Plan, Shell Expansion Drawing and Non-Destructive Testing Diagram did not require DRA's but provided substantial savings through extensive use of stored data.

Figure 17. Inboard Profile: Two of the most popular N/C drawings were the inboard and outboard profile. This view was used at varying scales as the format for several working plans as well as in conjunction with the preparation of the unit erection schedule and several promotional pieces.

IMPLEMENTATION AND RESULTS

A hull designer with no computer experience was trained in the use of the AUTOKON language and assigned full time to develop and code the drafting macros (DRA's) and major structural systems as shown on contract level plans. The cognizant designers/draftsmen prepared the plan format specification, coded the input data for the necessary windows and operated the N/C plotter which drew the format or other graphical data. This personal involvement created interest and enthusiasm which led to good acceptance of the method. The value to the designer/draftsperson is relief from the tedious researching and drawing of lengthy and repetitive structural geometry as well as increased confidence in the reliability and accuracy of the data provided.

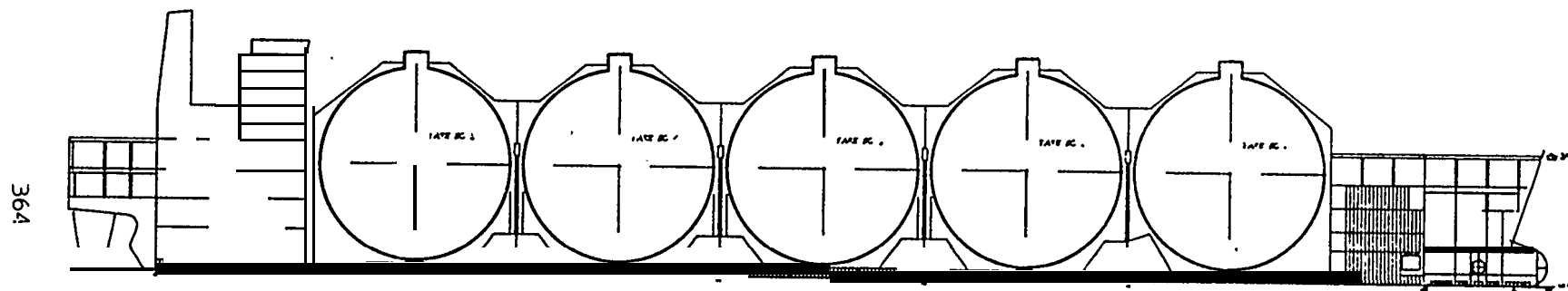


FIG 17

A total of 77 plan formats, or 11 percent of the 693 plans required for the design, were prepared in support of the LNG drafting effort. The method was conceived and macros developed concurrently with the LNG plan production effort, thus precluding its use on those plans with early start dates. The percentage of plans formatted is expected to increase significantly on future contracts since the method is now implemented and the DRA's and related N/C system macros completed. The method can now be applied to plans with early start dates such as those structural unit plans required to support early steel fabrication. In the structural area, 36 percent of the plans were drawn from formats, while 13 percent of the piping and mechanical plans used this semi-automated method. In addition to the plan formats, 44 development sketches were prepared for structural application and 30 for piping and mechanical tasks. Our experience on this design indicates that future use of the method will include a significant number of engineering drawings and electrical plans.

A total of about 272 hours of N/C plotter time or about 2-1/2 hours per plan were required to produce the formats and sketches. The plans for this design were drawn using ink on tracing cloth. This combination limits the speed of the plotter to about 30 percent of maximum. Ink on mylar allows full speed operation and would reduce plotter usage. Another 200 or so hours of plotter time were used in developing DRA's, structural systems and proving "windows". However, use of the plotter extended over an 18 month period, and no significant conflict with the validation of the N/C data for production parts occurred.

The labor savings for the LNG design, the first contract for which the method was implemented, were greater than anticipated. The experience gained through its use should yield even greater returns on future design efforts.

The savings in labor realized for each individual application of the method was estimated by the designer and his supervisor and noted on the related

Plan Format Specification. The total of these estimates indicate an average 10 percent saving in manhours to produce each plan.

The development costs of creating the basic drafting macros and any changes or additions to the N/C system related to the method are on the order of 500 hours, and the cost to code the 86 structural systems to support the LNG plans was an additional 1000 hours. The labor hours to produce the “windows” and the drawing of plan formats on the N/C plotter were about 1/3 of the hours saved and were included in the cost to produce the related plan. The computer costs will vary for each installation but can be estimated using experience with Parts Definition programs as a basis.

The method depends on several factors which may limit its success at some shipyards. Accurate structural system data must be available early enough in the design cycle to allow adequate time for coding and storing prior to scheduled plan starts. Cost effectiveness of the method will be reduced when working plans are not drawn by construction unit, since the windowing approach reduces the coding effort required. Also, any requirement to keep the stored data current will quickly erode any savings, since it is far more economical to handle changes on the original tracing as with manual drafting.

CONCLUSION

Application of the AUTOKON I Parts Definition Language to the production of LNG working plans established the feasibility of computer aided drafting using N/C languages.

The extent of savings possible by this method depends primarily on the type of plans produced. Those plans allowing maximum repetitive use of stored data will yield greatest returns.

While AUTOKON I was used in the case illustrated, the same techniques can be readily applied to other N/C system languages and utilized by any shipyard with an N/C parts coding capability. The coding skill required to produce the necessary macros is well within the level required to support a normal parts coding effort.

Additional copies of this report can be obtained from the
National Shipbuilding Research and Documentation Center:

<http://www.nsnet.com/docctr/>

Documentation Center
The University of Michigan
Transportation Research Institute
Marine Systems Division
2901 Baxter Road
Ann Arbor, MI 48109-2150

Phone: 734-763-2465
Fax: 734-763-4862
E-mail: Doc.Center@umich.edu